VISIT…

Chapter 4

General Purpose R&O Oils

The preceding chapter dealt with lubricant testing and also introduced lube-related technical terms that describe the various and sundry attributes and performance parameters. Our write-ups often culminated in the subheading "significance of results" and the reader may wish to refer back to these subheadings when asked to choose between competing lubricants.

That said, let's start by discussing R&O oils, the "workhorse lubricants."

The very first non-aqueous lubes were base oils—plain, non-additive base oils. But when the machinery was subjected to moisture, heat and oxygen, the oil oxidized. The introduction of moisture also led to rust, which began its corrosive creep. The result: breakdowns. . . blowouts. . . and, finally, replacement of expensive machinery.

But with the discovery of how to add certain ingredients to the base oil to help control rust and resist oxidation, lubricants developed broad, universal use.

R&O (rust and oxidation inhibition) has now become part of the language of lubrication for industrial machinery. R&O oils have become the workhorse lubricants in thousands of applications.

As of 1998, one such line of high quality lubricants, Exxon TERESSTIC®, has been in use for well over 50 years. Ongoing improvements to these products through the decades have given the TERESSTIC line an outstanding record of dependable service, whether as a hydraulic fluid, gear oil, heat transfer fluid or self-lubricating bearing oil.

ARE ALL "R&O" OILS THE SAME?

A common misconception is: "R&O oils are really all the same because they're mostly just oil." R&O products do contain "mostly oil," but the small concentration of carefully selected additives in proprietary basestocks that make up some superior lines of lubricants provide several key advantages:

- Base oil made from a dedicated crude source for most grades
- Refining by proprietary processes for optimized hydrocarbon composition
- Advanced systems for additive treatment, based or proprietary technology and understanding of the fundamentals of additive and lubricant behavior

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- Reliable quality control procedures to ensure a highly consistent, superior product

These factors lift some oils above ordinary R&O lubes.

ADDITIVE FORMULATION

A key reason why TERESSTIC®, for instance, is not an average R&O oil: its state-of-the-art additive formulation. The additive formulation in the TERESSTIC® line is a sophisticated system of inhibitors designed for maximum potency. The combination of premium quality base oils plus advanced additive systems in the lubes provides qualities essential to premium R&O oils:

- Rust protection with film tenacity for persistent action
- Oxidation resistance for long service life of the oil without acid formation or sludge, even in the presence of catalytic metals
- Thermal stability to minimize deposit formation during prolonged exposure to high temperatures
- Demulsibility for rapid separation of water that becomes entrained in the lubrication system
- Foam and air entrainment control to ensure maximum lubrication efficiency
- High VI to avoid wide viscosity swings when variations in temperature occur
- A full range of viscosities to satisfy the wide range of machine conditions (Table 4-1)
- Low pour points to ensure oil flow at startup

Table 4-1. Viscosity grade range for TERESSTIC® R&O lubricants.

Grade	32	32	46	68	77	100	150	220	320	460
ISO viscosity grade	32	32	46	68	—	100	150	220	320	460
Viscosity:										
cSt @ 40°C,										
ASTM D 445	32.3	30.0	44.2	65.1	78.7	105.0	157.5	214.0	306.0	432.0
cSt @ 100°C	5.3	5.2	6.5	8.4	9.5	12.1	15.7	18.7	23.8	30.3
SUS @ 100°F,										
ASTM D 2161	166	158	228	339	410	546	840	1123	1620	2284
SUS @ 210°F	44.2	43.8	48.1	58.5	66.5	80.0	93.0	115.0	149.0	

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DESIGNING A LINE OF R&O LUBRICANTS

The TERESSTIC® line of premium quality circulating oils was designed to lubricate and protect industrial machinery in a wide variety of applications. To meet the varied conditions of use, the TERESSTIC® line comprises a broad range of viscosity grades.

TERESSTIC® grades 32 through 100 are used primarily in turbine and other circulating oil systems (Figure 4-1)—hydraulic systems, compressors, pumps and general-purpose applications. TERESSTIC® grades 150 through 460 are used primarily in light-duty gear and higher temperature applications. Viscosity data on these products are shown in Table 4-2.

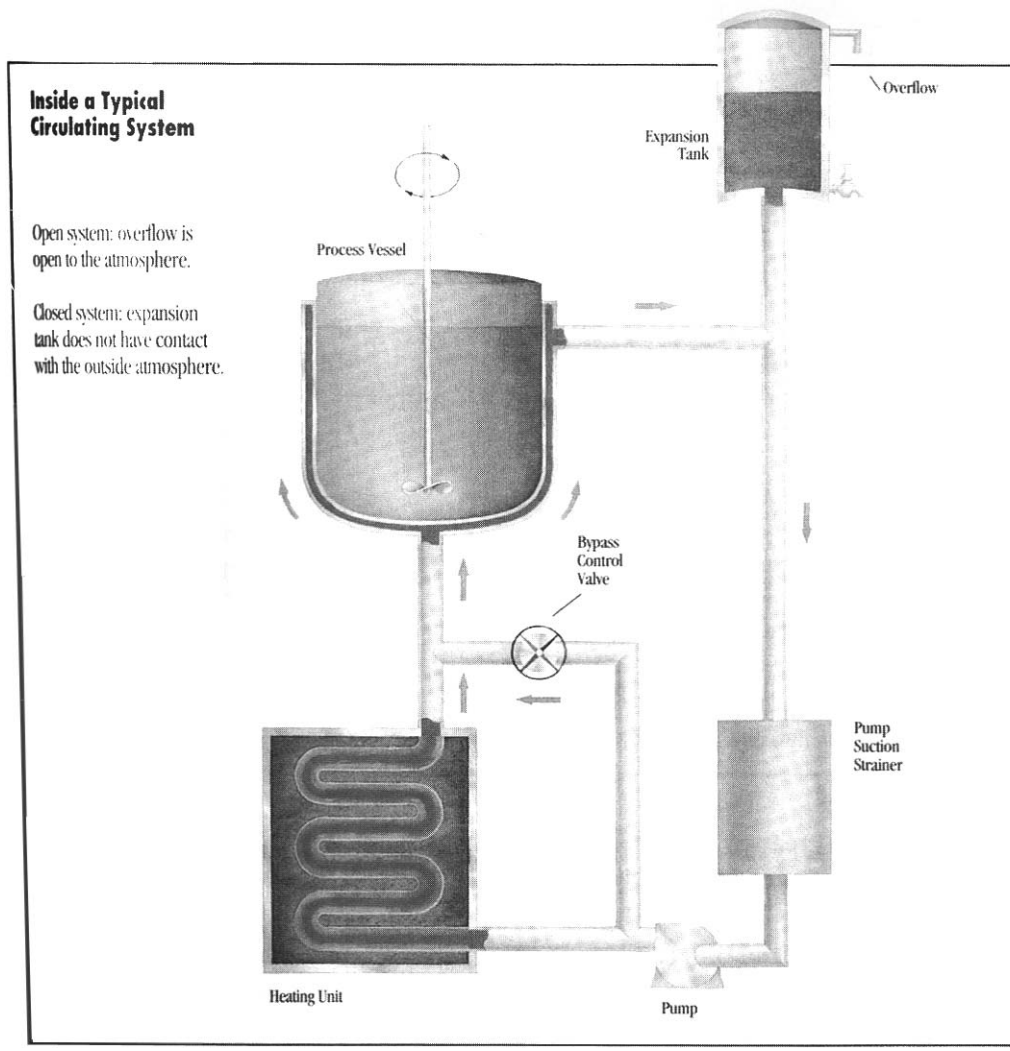

Figure 4-1. Elementary circulating oil system.

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Table 4-2a. Typical inspections for TERESSTIC® R&O lubricants.

	TERESSTIC				
Grade	**32**	**33**	**46**	**68**	**77**
ISO viscosity grade	32	32	46	68	—
AGMA lubricant grade	—	—	1	2	—
Viscosity:					
cSt @ 40°C, ASTM D 445	32.2	30.0	44.2	65.1	78.7
cSt @ 100°C	5.3	5.2	6.5	8.4	9.5
SUS@100°F, ASTM D 2161	166	158	228	339	410
SUS @ 210°F	44.2	43.8	48.1	54.4	58.5
Viscosity index	97	97	97	97	97
Gravity, specific @ 15.6°C(60°F)	0.877	0.873	0.877	0.879	0.880
°API	29.9	30.6	29.9	29.5	29.3
Flash point, ASTM D 92					
COC, °C(°F)	206(403)	207(405)	212(414)	224(435)	227(441)
Pour point, ASTM D 97					
°C(°F)	-37(-35)	-21(-6)	-21(-6)	-21(-6)	-21(-6)
Rust test ASTM D 665 A/B					
Distilled water	pass	pass	pass	pass	pass
Synthetic sea water	pass	pass	pass	pass	pass
Copper strip corrosion, ASTM D 130					
3hrs@ 100°C(212°F)	1	1	1	1	1
FZG Gear test, A/8.3/90, DIN 51354,					
Failure load stage (FLS)	—	—	—	—	—
Foam, ASTM D 892	pass	pass	pass	pass	pass
Water Separability, ASTM D 1401	pass	pass	pass	pass	pass
Neutralization No.	0.06	0.06	0.06	0.06	0.06
Oxidation life, ASTM D 943, hrs	5000+	2500	3000	2500	2000
Four-ball wear test					
scar diameter, 10 kg, 1800 rpm,					
150°C(302°F), 30 min, mm	—	—	—	—	—

Before the creation of the ISO viscosity grading system, it was customary to use the SAE grading system when selecting lubes for industrial applications. Refer to the appendix for a review of the approximate relationships between the grading systems.

EXTREME PRESSURE (EP) R&O LUBRICANTS

Three related products of special interest are Exxon's TERESSTIC EP 32, 46, and 68. These have the same high-quality base oil selection, additive treatment and performance

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Table 4-2b. Typical inspections for TERESSTIC® R&O lubricants.

TERESSTIC					TERESSTIC EP		
100	150	220	320	460	32	46	68
100	150	220	320	460	32	46	68
3	4	5	6	—	—	1	2
105	157.5	214	306	432	30.3	44.2	64.8
12.1	15.7	18.7	23.8	30.3	5.2	6.5	8.4
546	840	1123	1620	2284	157	228	336
66.5	80	93	115	149	44	48.1	54.4
97	95	95	95	95	97	97	97
0.887	0.890	0.888	0.897	0.894	0.877	0.877	0.879
28.0	27.5	27.9	26.2	26.8	29 9	29 9	29 5
257(495)	266(511)	266(511)	277(531)	307(585)	210(410)	212(414)	224(435)
-18(0)	-18(0)	-18(0)	-9(16)	-9(16)	-21(-6)	-21(6)	-21(-6)
pass	pass	pass	pass	pass	pass	pass	pass
pass	—	—	—	—	pass	pass	pass
1	1	1	1	1	1	1	1
—	—	—	—	—	—	11	—
pass	pass	pass	pass	pass	pass	pass	pass
pass	pass	pass	pass	pass	pass	pass	pass
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
1500	1250	1000+	1000+	1000+	2500+	2500+	2500+
—	—	—	—	—	0.28	—	0.26

characteristics of the other TERESSTIC grades plus added anti-wear protection.

Certain geared turbines—steam and gas—are subject to shock loads and occasional overloading. This creates extreme pressure that can force the normal lubricating film out from between meshing gear teeth. The resulting grind of metal-to-metal contact can cause excessive wear. TERESSTIC EP is formulated with a non-zinc anti-wear additive to help reduce the possibility of metal-to-metal contact.

User experience proves these lubes to be effective in reducing wear rates in turbine gears and system components under extreme-pressure conditions.

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And—like the other products in the line—TERESSTIC EP has an extremely effective oxidation inhibitor to help assure long, dependable operating life. All three TERESSTIC EP oils contain rust-inhibiting and anti-foam agents. They exhibit no rusting in either distilled water or synthetic sea water in the standard ASTM D 665 rust test procedure.

The TERESSTIC EP oils have extremely good demulsibility: any condensed moisture collecting in the lubricating system is readily shed by the oils. They also have a high viscosity index (VI), which allows more uniform operation of the system throughout a wide range of ambient and operating temperatures.

Dependable Turbine Lubrication

A few products have achieved a long record of reliable lubricant performance in the lubrication of steam turbines and gas turbines. For many years, the power industry has recognized the TERESSTIC line's ability to provide:

- Long life without need for changeout
- Prevention of acidity, sludge, deposits
- Excellent protection against rust and corrosion, even during shutdown
- Good demulsibility to shed water that enters the lubrication system
- Easy filterability without additive depletion
- Good foam control

An example of excellent performance value: TERESSTIC 32. Setting performance standards for turbine oil in the power industry, TERESSTIC 32 has been used in some cases for *over 30 years without changeout.* Results of controlled laboratory performance tests using TERESSTIC 32 are shown in Table 4-3.

Cleanliness Levels

Compressor lubrication can be one of the most demanding jobs for a lube oil because all compressors generate heat in the compressed gas. This heat directly impacts lube oil life. The degree of impact depends upon the compressor type and the severity of operation. In some units—reciprocating or rotary type—the lubricant is *directly* exposed to the compressed gas.

This stress can cause rapid oxidative degradation and resultant formation of deposits and corrosive by-products leading to increased maintenance needs. But superior oils meet and beat the compressor lubrication challenge.

What makes a line of lubricants successful in compressor applications?

- Special resistance to oxidation under conditions of high temperature and intimate exposure to air
- Good demusibility during water condensation
- Long-lasting rust and corrosion inhibition
- Anti-foam properties

Proper lubricant selection is crucial to compressor life and service. TERESSTIC oils are a cost-effective option for many compressor applications.

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Table 4-3. TERESSTIC 32: Premium quality turbine oil

Test Methods	Typical Result
Oxidation life	
Turbine oil stability test, ASTM D 943	5000+ hours
Staeger oxidation test	3300+ hours
Universal oxidation test	800+ hours
CIGRE test, total oxidation product	Pass, 0.3g/100g oil
Rust protection, ASTM D 665 A/B	Pass
Distilled water	Pass
Synthetic sea water	Pass
Film tenacity test	Pass
CEICO test	Pass
Copper corrosion, ASTM D 130	Pass, 1A
Water separability	
Emulsion test @ 54°C(130°F), ASTM D 1401	Complete separation
Foam control	
Foam tendency/stability, ASTM D 892, ml	20/20
Viscosity index	97

The main types of compressors and the TERESSTIC grades generally used at some of the most profitable refineries, utilities, and petrochemical plants are shown in Figures 4-2 through 4-4. Specific grade selections are discussed in the text segment dealing with compressor applications and depend both on manufacturer recommendations and on the expected operational severity. The TERESSTIC grades are particularly suited for use in dynamic and rotary compressors and light-duty reciprocating units.

SUPERIOR R&O OILS COVER A WIDE RANGE OF PUMPS

Like compressors, industrial pumps come in many shapes and sizes and serve thousands of industries. The selection of the proper pump depends on: the nature of the liquid being pumped (its viscosity, lubricating value, density, volatility, corrosivity, toxicity, solids content), the pumping rate, desired pressure and the type of lubrication system to be used.

The centrifugal pump is the most widely used in the chemical and petroleum industries for transferring liquids of all types: raw materials, materials in process and finished products. Characterized by uniform (nonpulsating) flow and large capacity, the centrifugal pump is also used for water supply, boiler feed and condensate circulation and return.

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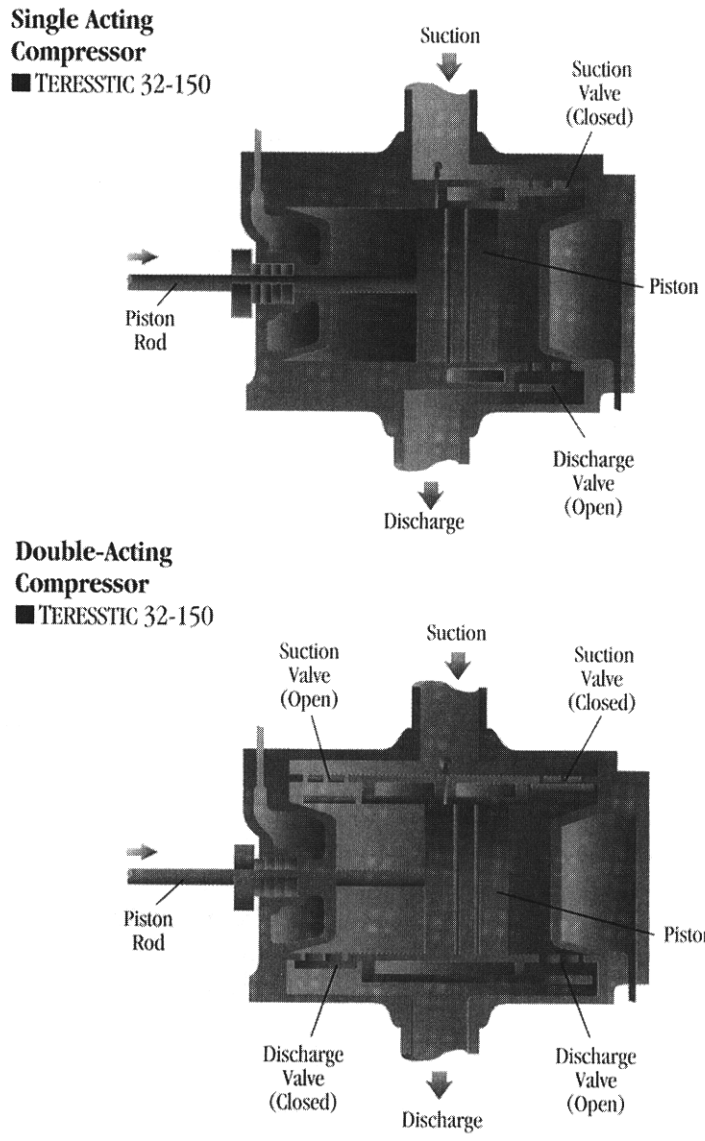

Figure 4-2. Reciprocating compressor applications.

Reciprocating and rotary pumps are particularly well adapted to low-capacity, high-pressure applications. They can deliver constant capacity against variable heads. Very close tolerances are required between internal rubbing surfaces in order to maintain volumetric efficiency, so the use of reciprocating or rotary pumps is generally restricted to liquids that have some lubricating qualities. Rotary and reciprocating pumps are used in fuel, lube circulating and hydraulic oil systems.

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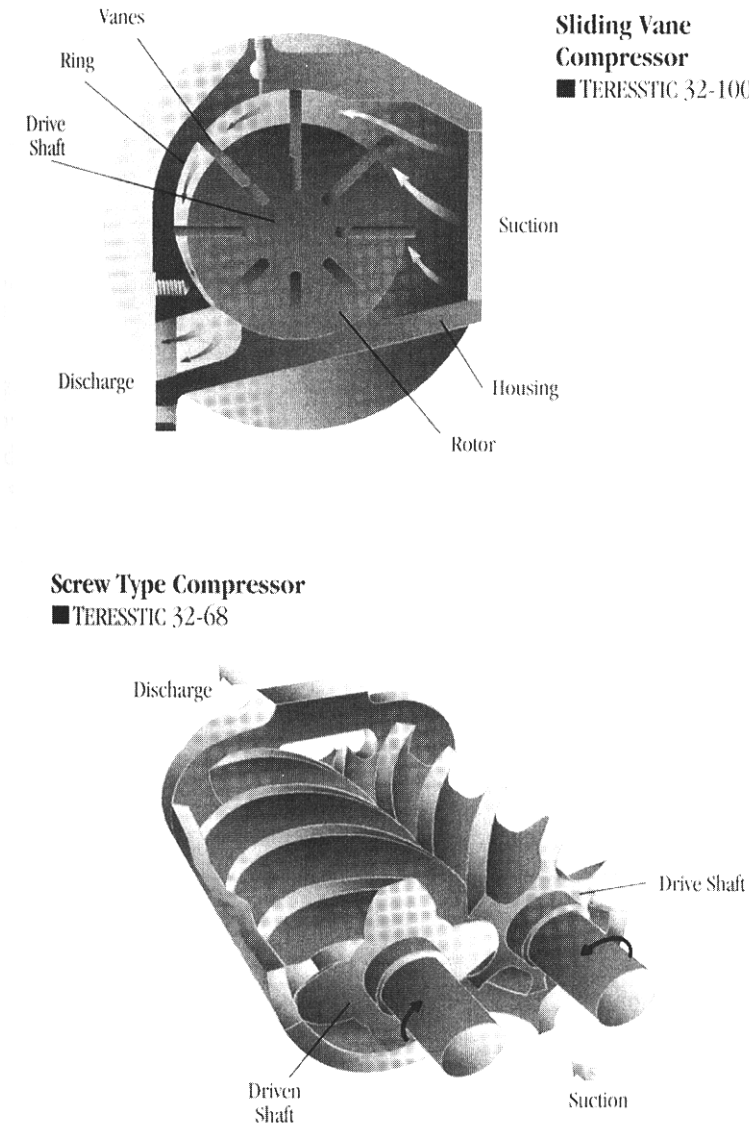

Figure 4-3. Rotary positive displacement applications.

In some pump designs—hydraulic pumps, for example—the fluid being pumped also serves as the lubricant for the pump. In others, the lubricant is supplied by an external system sealed from the pumped liquid. The lubrication system delivers oil to the pump shaft bearings, packing, seals and gear reducers.

TERESSTIC products are well-suited to many pump operations. They can serve as the external lubricant for the pump itself, drive motor bearings or other lubricated parts

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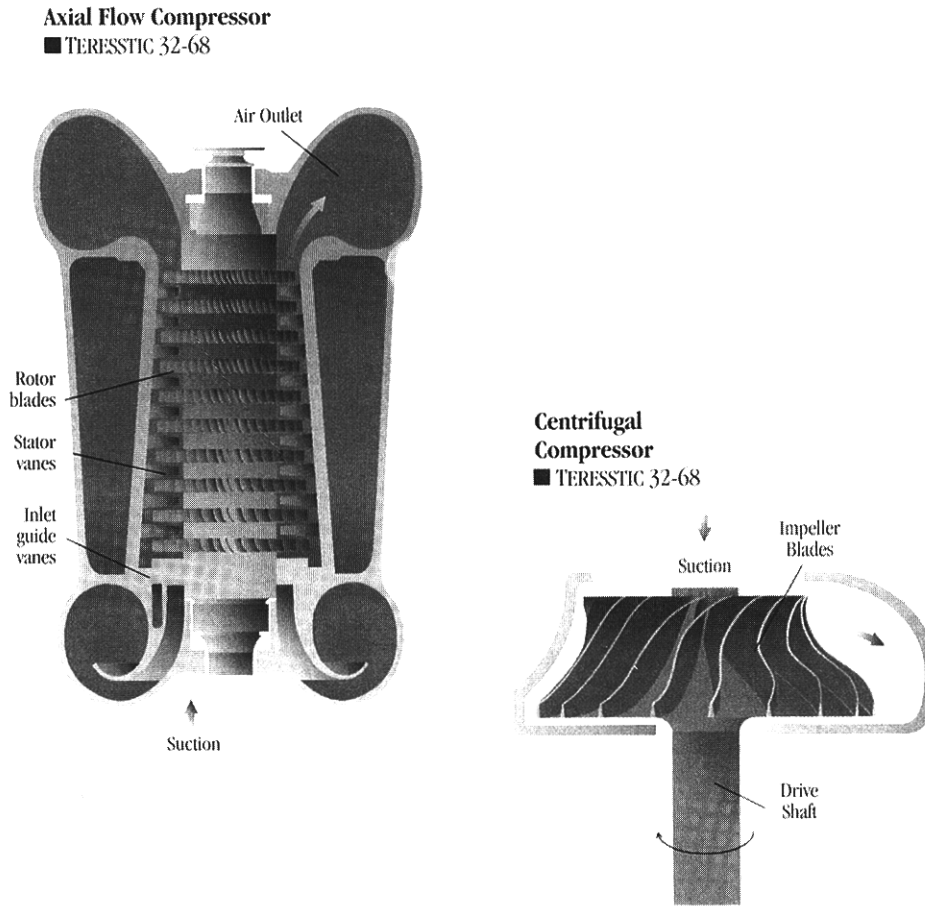

Figure 4-4. Dynamic compressor applications.

in the pump system. *However, TERESSTIC and similar R&O oils should not be used in portable water systems.*

Recommendation of the right TERESSTIC product for a given pump can be determined by the pump manufacturer's specification or by contacting the appropriate sales office.

While some of the pumps being lubricated with TERESSTIC oils include all types of centrifugal, mixed, and axial flow units, many others fall into the positive displacement category. These include piston, plunger, diaphragm, sliding vane, gear, lobe, and screw pumps.

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HYDRAULIC APPLICATIONS FOR R&O OILS

In hydraulic power applications, the TERESSTIC product line has a long record of customer satisfaction. TERESSTIC oils, especially grades 32-150, are particularly well suited for general-purpose hydraulic systems that do not require anti-wear protection but do require a premium quality oil with long life, and for pump components requiring full hydro-dynamic film lubrication. Exxon's NUTO® H (see Chapter 5) hydraulic oils with special anti-wear features are normally recommended for equipment that has especially high loading at the pump component surfaces, such as vane pumps.

Selecting the proper viscosity grade is important for the most effective hydraulic system lubrication. Items to consider during selection: the expected ambient environment and the extremes of oil temperature expected in the system.

Figure 4-5 shows viscosity change of TERESSTIC hydraulic oils with temperature. It also shows the recommended viscosity range at operating temperatures, as well as recommended maximum viscosities at startup temperatures. The bar graph in Figure 4-6 indicates the operating ranges and minimum startup temperatures for the TERESSTIC grades (grades 32 through 150 are most commonly used as hydraulic fluids).

Here's how you would use the viscosity graph shown in Figure 4-5.

Example 1: ***What TERESSTIC grades are appropriate at a pump operating temperature of 90°C?***

Locate 90°C on the bottom line and trace it upwards to the recommended viscosity range of 13-54 cSt. TERESSTIC grades 100 and above fall within that range.

Example 2: ***What TERESSTIC grades have viscosities that fall below the allowable maximum at a vane pump startup temperature of 10°C?***

Locate 10°C on the bottom line and trace it upwards to the horizontal line representing 860 cSt, the maximum startup viscosity for a vane pump. TERESSTIC grades 100 and lower fall below 860 cSt.

Next, some guidelines. Avoid choosing too-low viscosity grades for your systems to:

- Maintain sufficient hydrodynamic film thickness
- Prevent excessive wear of moving parts
- Avoid excessive pump slippage or case drain and loss of pressure system response

Avoid choosing too-high viscosity grades for your system to:

- Eliminate startup problems at low temperatures and avoid high wear during startup
- Reduce pump cavitation tendency
- Achieve good response in hydraulic system devices
- Ensure good defoaming and good demulsibility
- Save energy

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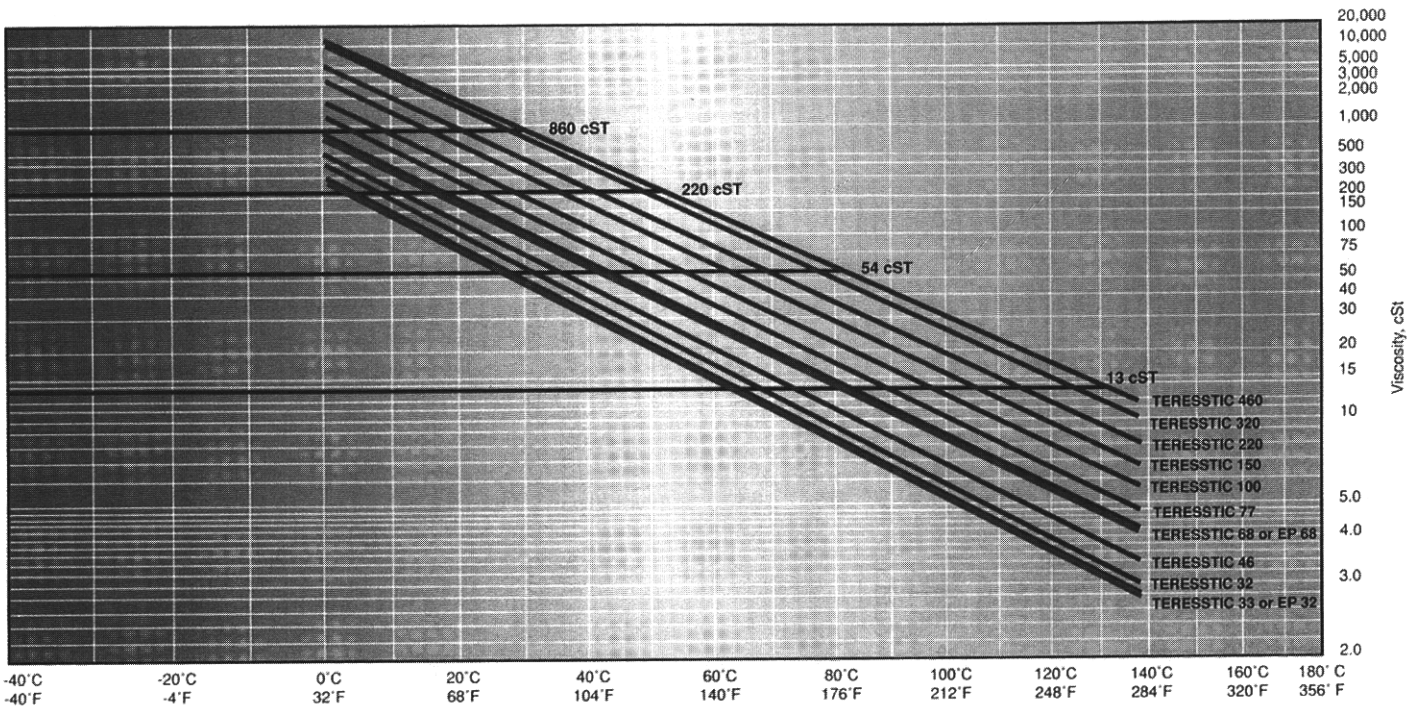

Figure 4-5. Viscosity-temperature curves for TERESSTIC® R&O oils widely used in industry.

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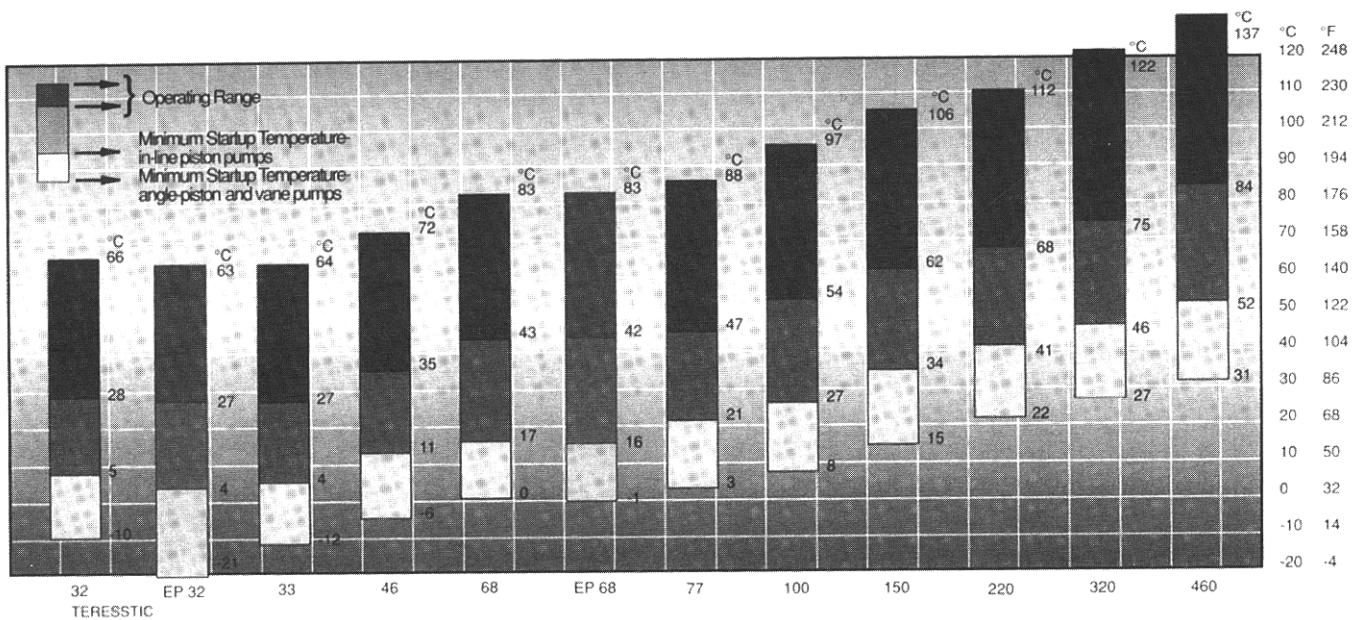

Figure 4-6. Operating temperature range of TERESSTIC® oils in hydraulic systems.

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UNIVERSAL APPLICATION OF R&O OILS

The almost universal applicability of superior R&O lubricants is best demonstrated by the fact that TERESSTIC grades are often used for gear lubrication, or as heat transfer fluids, or in self-lubricated bearings.

For lubrication of enclosed gear drives in industrial equipment, the manufacturer's recommendation for the proper lubricant grade is usually indicated on the gear case as the American Gear Manufacturers Association (AGMA) number. As discussed later in our chapter dealing with gears, these AGMA specifications cover a wide range of viscosity and load-carrying grades, from light-duty to severe applications. The most widely used are the grades of circulating lubricants. They can easily be distributed to gears and bearings for lubrication and heat removal, and are readily filtered and cooled.

For light-duty applications where extreme-pressure properties are not required, AGMA recommends the use of an R&O lubricant. The TERESSTIC grades meet essentially all of the requirements of AGMA grades 1-6 (see Appendix for details).

Typical gear types suitable for TERESSTIC oil use include: spur gears, helical gears, double helical (herringbone) gears, bevel gears and spiral bevel gears.

TERESSTIC oils—with their long-lasting rust inhibitor system, technologically advanced oxidation prevention and good demulsibility and foam control—provide excellent gear protection and R&O performance. They enjoy a long record of trouble-free use.

A HEAT TRANSFER FLUID THAT KEEPS ITS COOL

TERESSTIC oils are made from petroleum components that are vacuum-fractionated to selectively remove lower volatility elements. The components are then fully refined and additive-treated to provide outstanding oxidation resistance. These characteristics make TERESSTIC products excellent heat transfer oils.

In many process applications—industrial heat-treating, chemical manufacturing and food processing—there are clear advantages to carrying heat by means of fluid transfer systems rather than using direct-fired heating systems. Using fluids for heat transfer allows closer control of the process temperatures, eliminates hot spots in vessel walls, permits heating several process vessels using one primary heat source and provides better economy in the overall heating operation.

The working fluid used in the system must have a high degree of oxidation stability, especially in open circuit systems where the expansion tank is open through a breather tube and air can contact the hot oil. The fluids must not develop sludge or allow carbonaceous deposits on the primary heat exchanger walls, pipes or the heated reaction kettle. For safety reasons, the fluid should have volatility, i.e., low vapor pressure at the heat transfer temperatures. It should also have high flash and fire point properties.

Several TERESSTIC grades, because of their excellent resistance to oxidation and thermal degradation, are ideally suited for use as high-quality heat transfer fluids. They are capable of providing long service in a heat transfer circulating system. The grades are listed in Table 4-4, which also shows general guidelines on:

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- The maximum operating temperature—based upon safety considerations such as flash and fire points—for the fluid in the expansion tank, where some exposure to air may occur in open systems. (In less critical closed systems, considerably higher expansion tank temperatures may be used because no air contact occurs.)

- The maximum bulk oil temperature as it leaves the primary source heat exchange unit. (The actual film temperature or skin temperature next to the furnace tubes can be even higher, limited only by the ultimate thermal degradation property of the fluid.)

Table 4-4. Temperature guidelines for premium grade R&O oils in heat transfer applications.

Product	Flash Point	Maximum expansion tank temperature for open systems, COC,°C(°F)	Maximum bulk oil temperature for open or closed systems, °C(°F) °C(°F)
TERESSTIC 32	206(403)	185(365)	316(601)
TERESSTIC 46	212(414)	197(387)	316(601)
TERESSTIC 68	224(435)	209(408)	316(601)
TERESSTIC 77	227(441)	212(414)	316(601)
TERESSTIC 100	257(495)	242(468)	316(601)
TERESSTIC 150	266(511)	251(484)	316(601)

A brief tabulation of good practices in using heat transfer fluids might include a listing of general requirements, followed by a few memory joggers. Thus, in order to:

- Maximize the efficiency of the overall heat transfer operation
- Maximize the useful life of the fluid
- Minimize formation of deposits on walls and tubes

Remember to:

- Select a fluid of lowest feasible viscosity and the highest coefficient of heat transfer
- Use fluids that are effectively inhibited with non-volatile additive systems
- Avoid catalytic metals (i.e., copper alloys) in the system
- Do not use clay filters (i.e., avoid additive removal)
- Minimize air contact, avoid air leaks at pumps, etc.
- Do not mix different types of heat transfer fluids
- Do not use heating oil or solvent for flushing; use a mineral oil such as CORAY or FAXAM.
- Be watchful for oil leaks onto hot surfaces

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- Use an oil with flash point at least 15°C (27°F) above expansion tank temperature
- Never operate either open or closed systems at temperatures near the auto-ignition point; keep the system below 360°C (680°F).

It is important to give close attention to flash points and maximum temperatures, as given in Table 4-4.

TERESSTIC USE IN SELF-LUBRICATING BEARINGS

Development of lubricated-for-life bearings has brought us electric shavers, kitchen appliances, power tools (Figure 4-7), automotive electric motors and a host of other conveniences we take for granted. The bearings, lightweight and complex in design, never have to be relubricated.

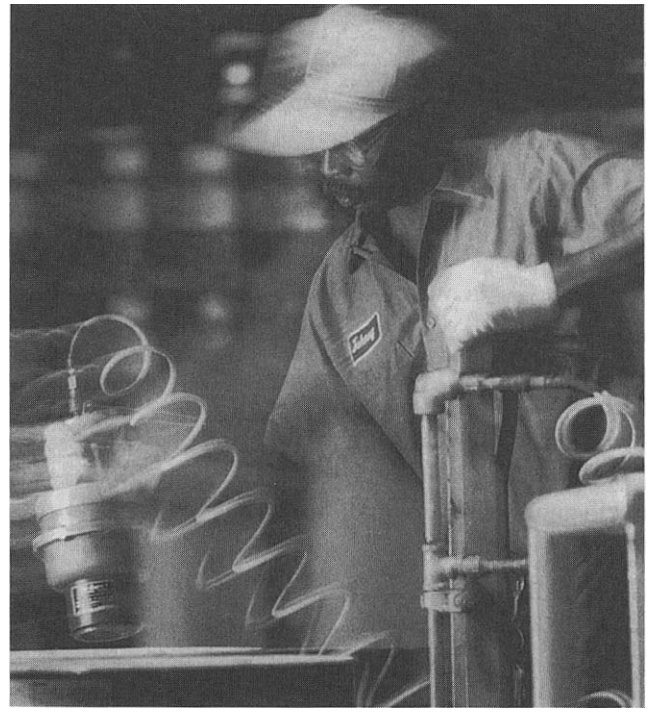

Figure 4-7. The extraordinary loads placed on the self-lubricating bearings of high-speed power tools can lead to premature tool failures without the protection of quality oils.

Self-lubricating bearings have evolved from the steadily emerging technology of powder metallurgy. Their success depends on having an oil impregnated into the metal of the bearing that is capable of lifelong, trouble-free operation.

A self-lubricating bearing is typically made in four steps:

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(1) A selected metal or alloy is reduced to powder—usually by atomization of a molten stream—to a specified particle size and distribution.

(2) The powder is compacted in a mold to the dimensions of the intended finished part.

(3) The part is heated to sinter the powder, while leaving a controlled amount of internal space and capillary passageways.

(4) The part is impregnated with a lube-for-life such as TERESSTIC.

The oil absorbed into the pores of the sintered metal acts as a reservoir for lubricant when the part is in use. At startup a thin film on the surface provides initial lubrication. As the bearing warms up, the oil expands and is forced out of the pores into the space for journal/bearing lubrication. When rotation stops and the bearing and oil cool, the oil is drawn back into the pores of the bearing by capillary action. Conventional powder metallurgy (P/M) bearings can absorb about 10-30% by volume of oil. The thin film of oil and the small reservoir within the pores do the whole job of lubrication. There is no circulating system or oil reservoir in the conventional sense.

There are significant advantages to this technology:

- The finished part is less dense than a conventionally machined part; weight savings are of great importance in many applicators.
- Controlling of powder metallurgy adds strength and durability to the part.
- The P/M system eliminates the need for conventional machining, saving time and allowing fabrication of more complex shapes.
- Self-lubricating bearings simplify design considerations in the unit of machinery.
- High-quality self-lubricating bearings eliminate the need for maintenance or repair service and reduce the cost of warranty claims.

P/M parts are particularly effective where relatively light loading is present: home appliances, automotive accessory equipment, power tools, business machines and the like. Selection of high-quality oil is extremely important:

- The oil must be fully refined to provide maximum stability without forming gums, varnish or sludge that would block the porous structure.
- Additives in the oil should have high permanence but should not interact with the sintered metals or otherwise cause corrosion or deposits.
- The viscosity grade must provide the proper hydrodynamic lubrication under the

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conditions of use both at startup and at maximum operating temperature.

Based on field experience, TERESSTIC grades 68 and 77 have been used most frequently in making self-lubricating parts. In fact, TERESSTIC 77, a special grade not in the established ISO grade sequence, was specifically formulated for application in self-lubricating bearings.

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